

Title Page

Title: The effect of Pain Neurophysiology Education on physiotherapy students' understanding of chronic pain, clinical recommendations, and attitudes towards people with chronic pain: a randomised controlled trial.

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ABSTRACT

Objective: To investigate the effect of Pain Neurophysiology Education (PNE) on student physiotherapists': 1) knowledge of chronic pain; 2) attitudes towards patients with chronic pain and; 3) clinical recommendations for patients with chronic pain.

Design: Multi-centred single-blind randomised controlled trial.

Setting: One UK and one Irish University.

Participants: Seventy-two student physiotherapists.

Intervention: Participants received either a PNE (intervention) or a control education. Both were delivered in a 70-minute group lecture.

Main Outcome Measures: 1) the Revised Pain Neurophysiology Quiz to assess knowledge; 2) the Health Care Pain Attitudes and Impairment Relationship Scale (HC-PAIRS) to assess attitudes; and 3) a case vignette to assess appropriateness of clinical recommendations.

Results: Post education, the PNE group had a greater increase in pain neurophysiology knowledge 4.0 (3.2 to 4.7), $p < 0.01$ [mean difference (95% Confidence Interval), p-value] and more improved attitudes -17.5 (-22.1 to -12.9), $p < 0.01$. Post-education, students in the PNE group were more likely to make appropriate recommendations with respect to work (94% vs. 56%), exercise (92% vs. 56%), activity (94% vs. 67%) and bedrest (69% vs. 33%) compared to those in the control group ($p < 0.05$).

Conclusion: The improvements in knowledge, attitudes and recommendations for pain management show that PNE is a potentially valuable part of physiotherapy student education, which could be used on a more widespread basis. There is a need to investigate whether these findings can be replicated in other health care professions, and how well these reported changes lead to changes in actual clinical behaviour and the clinical outcomes of patients.

Contribution of the paper

- **This is the first randomised controlled trial to investigate the effect of pain neurophysiology education (PNE) on undergraduate physiotherapists.**
- **PNE can increase physiotherapy students' knowledge of pain neurophysiology, improve their attitudes towards patients with chronic pain, and increase the likelihood that they will make recommendations in line with clinical guidelines.**
- **PNE could be a useful component of the standard undergraduate curriculum though further studies are required to confirm this.**

1. Introduction

Pain education is important for undergraduate health care professionals (HCPs). The quantity and quality of undergraduate pain education across multiple HCPs has been questioned [1-8]. A UK survey, found that **undergraduate pain education amounted to just** 12 hours equating to <1% of total teaching time [6]. Adherence to the International Association for the Study of Pain (IASP) curriculum guidelines was scant. There is a need for undergraduate pain training enhancement.

IASP has published a number of pain curricula for undergraduates [9-11]. While uptake appears limited [6], reports have been published where the IASP curriculum has been utilised [4, 12, 13]. Initial results for such curricula are positive with respect to improved student knowledge and attitudes. However, findings have come from uncontrolled studies, thus improvements cannot be attributed to the educational input [4, 12, 13].

Pain education **can be** delivered in many different formats. A relatively distinct format is Pain Neurophysiology Education (PNE). Over 15 years, PNE has grown in popularity as an

intervention for patients with chronic pain [14]. PNE uses neurophysiology information to teach people that pain can be overprotective and completely real even in the absence of tissue injury [14]. PNE can improve patients' knowledge and attitudes towards pain [15-22]. It can also improve pain knowledge in clinicians [15], the logic of which suggests that it may be useful for students. PNE's potential for student education is seen further as it addresses at least some of the learning objectives of the IASP curriculum. A recent US study [23] found that doctoral physical therapy students' knowledge of pain was improved by PNE. However, as this study was uncontrolled the improvement cannot be attributed to PNE alone. The aim of this randomised controlled trial (RCT) was to investigate the effect of PNE compared to a control education on students': 1) knowledge of chronic pain; 2) attitudes towards patients with chronic pain and; 3) clinical recommendations for patients with chronic pain.

2. Methods

2.1. Design

This was a multi-centred single-blind randomised controlled trial (RCT) of physiotherapy students' knowledge, attitudes and behaviours towards patients with chronic pain. Students received either PNE or a control education. There were three outcome measures analysed pre and post both education interventions: 1) the revised PNE quiz [24] 2) the Health Care Pain Attitudes and Impairment Relationship Scale (HC-PAIRS) [25]; and 3) a case vignette to indirectly measure clinical behaviour [26, 27]. There were no protocol violations. This trial has been reported following CONSORT guidelines [28].

2.2. Participants

Students were eligible to participate if they were undergraduate physiotherapists enrolled at either XX University, UK or the University of XX, Ireland. Individuals were excluded if they

had previously received in-depth teaching on pain neurophysiology or red flags. At XX University, individuals in Years 2 and 3 were excluded as they receive an in-depth session on PNE as part of their usual education. Therefore, only year 1 students were eligible for this study. For the same reason, only students in Years 1 and 2 were eligible for inclusion at the University of XX. Participants were recruited via all-student email invitations. All participants provided written informed consent. This study received ethical approval from the research and ethics boards at both universities and was conducted in accordance with the Declaration of Helsinki, 1975. Data collection occurred between October 2014 and February 2015. An a priori sample size calculation was not undertaken.

2.3. Interventions

Both the PNE and control education sessions were delivered by XX at XX University and XX at the University of XX. Both are qualified physiotherapists for ≥ 5 years, with experience of teaching pain neurophysiology at university level. Both have received training on PNE on Neuro Orthopaedic Institute (NOI) educational courses. Both education sessions were 70 minutes in duration and delivered in a didactic group-lecture style. The same PowerPoint slides were used at both universities. Each education session had a brief case study towards the end of the lecture. There was the opportunity to ask questions but group discussion was minimal due to time constraints.

The control group received an education session on red flags. Red flags are questions used in clinical practice to screen patients for serious or sinister pathology [29]. The control session discussed Waddell's triage for classifying patients with back pain into one of three categories - either serious or sinister pathology, nerve root compression or non-specific low back pain [30]. Serious and sinister physical spinal pathology were then discussed in detail. Psychosocial

issues were not discussed beyond the importance of not unduly worrying the patient when discussing red flags. The red flags session did not discuss pain neurophysiology; instead it exclusively dealt with tissue pathology and the detection of this pathology. The control education focused on red flags because it provided an attention-control whereby students were engaged in learning about a topic, which in this case had clear face validity for pain education, but was clearly different from the content of the intervention.

The intervention group received a PNE session. The material was based on the first four chapters of the *Explain Pain* manual [31]. Free-hand drawings, stories and metaphors were used to convey messages about pain physiology and theory. The session explained to students that **the nervous system can become** over-protective and that nociceptive transmission can be influenced by the sensitivity of the central nervous system as well as an individual's thoughts, beliefs and contextual environment.

2.4. Outcomes

Immediately before and after the education session, participants completed three questionnaires; **the revised Pain Neurophysiology Quiz, The modified 13-item Health Care Pain Attitudes and Impairment Relationship Scale (HC-PAIRS), and a case study vignette.** Participants were also asked to identify their age, sex and year of study. A **written quiz related to** knowledge of red flags was also given to all participants **before and after the education sessions.** This **has not been validated** and was not used as an outcome measure but rather to facilitate participant blinding by ensuring there were questions relevant to the educational session delivered for both groups. Details of the red flag quiz are presented **in supplementary material Appendix A.**

2.4.1. Revised Pain Neurophysiology Quiz

The revised Pain Neurophysiology Quiz was used to assess students' knowledge of pain neurophysiology. Each item has a true, false or undecided response. Correct responses were awarded 1 point with incorrect (or undecided) responses awarded 0 points. Thus, scores can range from 0-13, with higher scores indicating greater pain neurophysiology knowledge. The Pain Neurophysiology Quiz is a valid and reliable tool for assessing pain physiology knowledge [15, 24].

2.4.2. The modified 13-item Health Care Pain Attitudes and Impairment Relationship Scale

The modified 13-item Health Care Pain Attitudes and Impairment Relationship Scale (HC-PAIRS) [25] was used to assess students' attitudes towards patients with chronic pain and their ability to function despite pain. Each item has a 7-point likert scale response ranging from strongly disagree (scored as 1) to strongly agree (scored as 7). Thus, scores can range from 13-91 with lower scores indicating more positive attitudes towards chronic pain patients. Items 1, 6 and 12 were reverse-scored as recommended. The HC-PAIRS is a valid and reliable measure of attitudes towards patients with chronic pain [25].

2.4.3. Case Study Vignette

A case study vignette was given to each patient before and after the education to assess their clinical behaviour with a chronic pain patient. The vignettes were adapted from previously published vignettes [26, 27]. The participants were asked to indicate, via **four** multiple-choice questions (adapted from Bishop et al., 2008 [26]), their recommendations about usual daily activities, work, exercise, and bed rest. The number and percentage of appropriate recommendations (i.e. in line with clinical guidelines [32]) were recorded. The vignette

questions and classification of responses are shown in Table 1. Participants were directed to answer specifically about the vignette rather than about general patients. Vignettes have been used previously to assess the effect of clinicians' attitudes on their management of patients with LBP [33] and are seen as a more accurate and valid measure of clinical behaviour than data extracted from case notes [34].

Insert table 1 here

2.5. Blinding & Randomisation

Upon volunteering, participants were randomised into either the PNE or **control** group using the random number generator function in Excel (Microsoft, Office Professional Plus 2013). Randomisation was completed in a concealed manner prior to meeting the participants. Participants were informed that the purpose of the study was to compare two different types of education for chronic pain, and thus, they were blind to PNE being the education of primary interest. The statistical analysis was not undertaken blindly.

2.6. Statistical Analysis

Descriptive statistics, pooled for both sites, were presented for all outcome measures before and after the intervention. **Having established appropriate normal distribution of data,** continuous data were presented as mean (SD) and categorical data were presented as percentages. Between-groups comparisons for the change in these measures, controlling for baseline values, were performed using analysis of covariance (ANCOVA).

With respect to the vignette, for each of the recommendations contingency tables were constructed with the appropriateness of the recommendations as the dependent variable and

educational group as the independent variable. The Mantel-Haenszel test was used to quantify the odds ratio and 95% confidence interval. Between-groups comparisons were made for the pre-education scores to assess baseline clinical recommendations and the post-education scores to assess clinical recommendations after receiving the respective education. All analyses were by original assigned groups.

3. Results

Eighty students, (80/106, 75%), volunteered (n=31 at XX University and n=49 at the University of XX) and were randomised. Prior to the study commencing, four participants from each group dropped out. Reasons for drop-out included illness, work commitments and family commitments. The characteristics of the 72 study completers are presented in table 2. The groups were similar at baseline.

The PNE group had a greater increase in pain knowledge as measured by the PNE quiz compared to the control (red flag) group (table 3). The PNE group also demonstrated a greater post-intervention shift in positive attitudes towards patients with chronic pain as indicated by the reduction in the HC-PAIRS scores (table 3). Finally, the PNE group were more likely to provide appropriate recommendations regarding daily activities, exercise, work and bed rest that were in line with clinical guidelines for patients with chronic pain following education as measured by the case study vignette (table 4). The non-validated red flags quiz was used to ensure adequacy of blinding rather than as an outcome measure. For complete reporting the before and after red flags quiz scores have also been reported in table 3 showing greater improvement in the control group compared to the PNE group. There were no adverse effects reported by any participants.

Insert tables 2, 3 and 4 here

4. Discussion

This study found that a single 70 minute PNE session can increase physiotherapy students' knowledge of pain neurophysiology, improve students' attitudes towards patients with chronic pain, and shift students' recommendations for pain management to be more in line with clinical guidelines, compared to a control education session.

In this study pain neurophysiology knowledge improved in the PNE group by 34% (45% - 79%). This is comparable to the 32% change (29%-61%) observed in patients and 23% (55% - 78%) observed in HCPs in a study carried out by Moseley (2003) [15], and the 43% (41% - 84%) observed in first year US doctoral physical therapy students under uncontrolled conditions [23]. Our findings demonstrate that UK and Irish undergraduates are able to learn the complex information provided within PNE to similar level as fully qualified HCPs.

We found an 18-point improvement in the HC-PAIRS score following PNE. Previous studies investigating other educational formats have reported a nine-point improvement between first and final year students' HC-PAIRS scores on UK physiotherapy [35] and medical degree programmes [36]. Latimer et al., [37] reported an eight-point improvement following a 14.5 hour programme over 4 weeks. While comparison between studies is difficult as the exact volume and content of education within the different studies is not provided, the magnitude of change with our brief input (70 minutes PNE) is double that previously reported with much longer duration educational interventions for health care students. Interestingly our findings contrast with a recent US uncontrolled study that found HC-PAIRS score was unchanged

(<1point) following PNE [23]. Reasons for this are unclear and may be linked with methodological differences such as the samples and settings.

Following the education sessions, compared with the control group, the PNE group were more likely to make clinical recommendations in line with clinical guidelines. There was a clear and consistent improvement in recommendations across all four domains in the PNE group, while the control group remained similar to their baseline recommendations. Post-PNE, appropriate recommendations for daily activities, work and bedrest were 94%, 94% and 69%. This can be compared with data from a UK nationwide survey of qualified physiotherapists and general practitioners where appropriate recommendations for daily activities, work and bedrest were, respectively, 72%, 93% and 99% [26]. This comparison indicates that clinical behaviour can be shifted in line with that of qualified health care practitioners following a single session of PNE.

An exploratory analysis found a statistically significant negative correlation between change in Pain Neurophysiology Quiz scores and HC-PAIRS ($r=-0.48$, $p<0.001$). This suggested an association between improved pain neurophysiology knowledge and positive attitudes to patients. Also, there were significant correlations between the post education Pain Neurophysiology Quiz scores and each of the post education vignette scales of activity, bedrest, exercise and return to work ($r=0.25$ to 0.42 , $p<0.031$). This suggests that those with more neurophysiology knowledge were more likely to make recommendations in line with current guidelines. Interestingly, for the red flags quiz scores the associations with HC-PAIRS and with the vignette scales were in the opposite direction (HC-PAIRS $r=0.52$, $p<0.001$: vignette scales $r=-0.09$ to -0.27 , p ranging from 0.024 to 0.441). As the red flags quiz has not undergone validity testing, we hesitate to make any significant interpretation on this observation, beyond

the possibility that the medical focus in the red flags education delivered in isolation may have influenced a cautious approach to back pain management.

4.1. Clinical Implications

These findings support the use of PNE for student physiotherapists. Furthermore, 70 minutes PNE brought about a large (relative to other educational interventions) positive change in attitudes towards patients, which have previously taken considerably longer periods to achieve [35-37]. This strengthens PNE's potential inclusion as a feasible and cost-effective education for a time-limited curriculum. The apparent enhancement of pain education via PNE within the undergraduate curriculum could have far-reaching implications for patients with chronic pain potentially increasing the likelihood they will receive evidence-based pain management.

4.2. Strengths and Limitations

One limitation of this work is the lack of a follow-up period to assess retention of knowledge and attitudes and behaviour change. Further work needs to investigate if these improvements are sustained and/or if top-up sessions are required. Another limitation is that direct clinical behaviour was not investigated. While vignettes are a good proxy measure of clinical behaviour [34], they are not without limitations [38]. Changing the beliefs of clinicians via a pain based educational programme does not necessarily result in different clinical behaviour or patient outcome [39, 40]. It would have been interesting to follow-up our participants into clinical practice to investigate if PNE had any effect on actual clinical behaviour and/or clinical outcomes.

A key methodological limitation was that the educators were not blinded. This could have been overcome by employing two independent educators blinded to the study aims to deliver the

educational sessions independently of one another. We did not have the resources to implement this. Additionally, a blind statistical analysis would have been more methodologically robust. We repeat the point that caution is advised in interpreting the results of the red flags quiz. It was designed and used as a facilitator of blinding and has not been subjected to any validity or reliability testing. That said, the red flags quiz scores did increase following the control education and did not change in the PNE group, implying a degree of validity. Formal validity testing would be useful future work. Finally, though identical slides were used at both universities, there was no set script. Thus, there may have been minor differences during the education sessions between sites. To investigate this, test sites were compared to identify if findings were consistent between universities. No statistical differences were found between sites with the exception of change in HC-PAIRS score in the control groups of -4.8 (8.7) vs. 2.2 (7.2) [means (SD)], $p=0.02$; and change in the pain neurophysiology quiz in the intervention groups of 5.6 (1.5) vs. 4.0 (2.2), $p=0.04$. However, the magnitude of the differences between sites are smaller than the differences between groups and the pattern of the PNE intervention group producing superior results in all outcomes was consistent across sites.

This study was restricted to a relatively small sample of physiotherapy students, early in their studies, in the UK and Ireland. Thus the findings may not generalise to students in the later years of their programme or other professions or other countries. There is a particular need to repeat this study with students from other professional groups given the importance of multidisciplinary management of chronic pain. In addition, more longitudinal work is warranted to identify if these changes can be identified from the first to final year of an undergraduate programme and if any changes observed translate into clinical practice.

5. Conclusions

This single-blind RCT found that a single 70 minute PNE session can, in the short-term, increase physiotherapy students' knowledge of pain neurophysiology, improve their attitudes towards patients with chronic pain, and increase the likelihood that they will make recommendations in line with clinical guidelines. The current findings would suggest that PNE would be a useful component of the standard undergraduate curriculum though further studies are required to confirm this. There is a need to investigate if these findings can be replicated in other health care professions, and how well these reported changes reflect changes in actual clinical behaviour and outcomes.

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Table 1: Case study vignette response options

Question	Response option on questionnaire	Classification of response
Work	Return to normal work	appropriate recommendation
	Return to part-time or light duties	
	Be off work for a further.... weeks (stating number of weeks)	inappropriate recommendation
	Be off work until pain has improved	
Exercise	Be off work until pain has completely disappeared	appropriate recommendation
	Return to normal exercise classes	
	Return to light class participation	
	Refrain from participating for a further ... weeks (stating number of weeks)	
	Refrain from participating until pain has improved	
Activity	Refrain from participating until the pain has completely disappeared	inappropriate recommendation
	Perform usual activities	
	Perform activities within the patient's tolerance	
	Perform only pain free activities	
Bed rest	Limit all physical activities until pain disappears	appropriate recommendation
	Avoid resting in bed entirely	
	Avoid resting in bed as much as possible	
	Rest in bed only when pain is severe	
	Rest in bed until pain improves substantially	
	Rest in bed until pain disappears	inappropriate recommendation

Legend: This table shows the case study vignette options for clinical recommendations regarding work, exercise, activity and bed rest. The first two responses are considered appropriate recommendations while the last two (or three) options are considered inappropriate options. The table is adapted from Bishop et al. (2008) [25] and Ryan et al. (2013) [26].

Table 2: Baseline participant characteristics

	Group	
	PNE	Control
Age (yrs)	20 (2)	20 (4)
Sex	20♀ 16♂	20♀ 16♂
Year of study (yr1/yr2)	25/11	17/19
Neurophysiology quiz (0-13)	5.8 (2.0)	6.4 (1.8)
Red flags quiz (0-10)	6.3 (1.5)	6.5 (1.2)
HC-PAIRS (13-91)	57.9 (6.1)	56.3 (9.0)
Appropriate Clinical recommendations:		
<i>Daily Activities (n, %)</i>	26 (72)	26 (72)
<i>Exercise (n, %)</i>	24 (67)	19 (53)
<i>Work (n, %)</i>	19 (53)	19 (53)
<i>Bed rest (n, %)</i>	10 (28)	10 (28)

Legend: Data are presented as means (SD) except for Sex and appropriate clinical recommendations. The data with respect to appropriate clinical recommendations indicate the number of participants who made appropriate recommendations in line with clinical guidelines regarding daily activities, exercise, work, and bed rest. HC-PAIRS = Health Care Pain Attitudes and Impairment Relationship Scale, PNE = pain neurophysiology education.

Table 3: Change in knowledge and attitudes between groups

	Group		Mean difference (95%CI)	p-value
	PNE Mean (SD)	Control Mean (SD)		
PNE quiz (0-13)	4.4 (2.1)	0.1 (1.9)	4.0 (3.2, 4.7)	<0.01
HC-PAIRS (13-91)	-18.6 (11.9)	0.3 (8.4)	-17.5 (-22.1, -12.9)	<0.01
Red Flags quiz (0-10)	-0.8 (2.2)	1.2 (1.4)	2.2 (1.5, 2.9)	<0.01

Legend: The change in pain knowledge and attitudes from before to after the education sessions. HC-PAIRS = Health Care Pain Attitudes and Impairment Relationship Scale, PNE = pain neurophysiology education, 95%CI = 95% Confidence Interval. The mean difference is the estimated mean difference from the ANCOVA adjusted for baseline values.

Table 4: Appropriate recommendations post-education between groups

	Appropriate recommendations, n (%)		OR (95% CI)	p-value
	PNE	Control		
Daily Activities	34 (94%)	24 (67%)	8.5 (1.7, 41.5)	0.01
Exercise	33 (92%)	20 (56%)	8.8 (2.3, 34.0)	0.01
Work	34 (94%)	20 (56%)	13.6 (2.8, 65.4)	0.01
Bed rest	25 (69%)	12 (33%)	4.5 (1.7, 12.3)	0.01

Legend: OR (95%CI) = Odds ratio (95% Confidence Interval), PNE = pain neurophysiology education group.

Appendix A: Red Flags Quiz

1. If someone answers yes to a red flag question that means they have a serious spinal pathology?

Answer: YES/NO

2. Loss of bladder control when sneezing/coughing/laughing is a red flag?

Answer: YES/NO

3. Altered sensation or numbness around the genitals/anus is a symptom of Cauda Equina Syndrome?

Answer: YES/NO

4. Individuals answering yes to any red flag question should be sent to A/E immediately?

Answer: YES/NO

5. An individual with a previous history of cancer is more likely to have cancer than an individual without a previous history?

Answer: YES/No

6. Individuals with red flags suggesting potential Cauda Equina syndrome should be sent to A/E immediately?

Answer: YES/NO

7. Recent weight loss regardless of the possible reasons for it should be considered a red flag?

Answer: YES/NO

8. The presence of multiple red flags is always more indicative of sinister pathology than one isolated red flag?

Answer: YES/NO

9. Depression is not a red flag?

Answer: YES/NO

10. The intensity of pain is a good marker of serious or sinister pathology?

Answer: Yes/No

Summary of red flags quiz

The 10-item Red Flags Quiz was used to assess students' knowledge of red flags. Each item had a Yes or No response. Correct responses marked as 'Yes' included items 2,3,5,6,8,9 and 10, with the remaining items 1,4 and 7 correctly marked as 'No'. A correctly answered question received a score of one and an incorrect answer received a score of zero. Total scores for the quiz could range from 0-10 with higher scores representing higher knowledge levels. The quiz was developed in-house by one of the authors (XX) specifically for this study as no appropriate questionnaire exists within the literature. Drafts of the quiz received comments from experts who have published in the area of red flags to support its face validity. It is acknowledged that the quiz requires further testing; however, in this study, it was used to facilitate participant blinding rather than being used as an outcome measure.